Peer Review Meeting Summary Report

External Peer Review of EPA's Draft Document

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

September 17, 2012

Peer Reviewers:

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EXECUTIVE SUMMARY

Versar, an independent EPA contractor, coordinated an external peer review of EPA's draft assessment, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* and organized and convened a three-day peer review meeting in Anchorage, Alaska on August 7-9, 2012. The peer review of EPA's draft assessment was initiated with a pre-meeting written peer review managed by Versar and conducted by 12 independent experts selected as peer reviewers. The role of the peer reviewers was to evaluate EPA's draft assessment and to provide a written review of the draft document (Volumes I-III) by responding to 14 Charge Questions put forth by EPA. Peer reviewers were charged only with evaluating the quality of the science included in EPA's draft assessment and were not charged with making any regulatory recommendations, commenting on any policy implications of EPA's role or mining development in the region, or reaching consensus in either their deliberations or written comments. The three-day peer review meeting, which directly followed the written peer review period, was organized as follows, with Days 1 and 2 being attended by approximately 220 members of the public:

- Day 1 of the meeting (Tuesday, August 7th) was dedicated to peer reviewers hearing oral comments from pre-registered public speakers. Approximately 95 members of the public shared oral comments with peer reviewers, related to assessment topics such as mining scenarios, effects on Alaska Native culture, effects on salmonid fish, and other areas.

- Day 2 of the meeting (Wednesday, August 8th), was dedicated to peer reviewer deliberations, which centered on individual responses to EPA's 14 Charge Questions.

- Day 3 (Thursday, August 9th) was a closed session to allow peer reviewers to document and summarize their major recommendations, after considering the public comments and deliberations of Days 1 and 2.

Day 3's documentation effort produced a Summary of Key Recommendations from Peer Reviewers, which is included in Section II of this report. Please note that neither the below summary list nor Section II of this report reflect a consensus or group perspective, but were compiled from a discussion of individual peer reviewer recommendations.

The reviewers commended EPA for an assessment of a challenging, complex scientific issue, working with data of variable quantity and quality. They offered numerous recommendations for improving the draft document, relating to scope, technical content, and clarity of presentation. While a more detailed description of the reviewers' recommendations is provided in Section II of this report, key recommendations for EPA's revisions to the document are highlighted below.

- The purpose and scope of the document should be clarified to correspond to the decisions that the assessment intends to support. This should include a statement of the intended audience(s) and range of decisions that the document could support, which would assist readers in understanding the approach, organization, level of detail, and uncertainties of the assessment.

- Accordingly, the document's organization should be consistent with ecological risk assessment guidance and build on the conceptual models presented in Section 3 that illustrate the framework for assessing potential effects of mine construction and operation on Bristol Bay watershed ecosystems.

- Clarify the geographic scope and coverage of the assessment (the entire Bristol Bay watershed or the Nushagak and Kvichak rivers' watersheds). Assess all rivers and streams that will be potentially influenced by the proposed mine (and its ancillary facilities, wastewater and solid waste management, and the transportation corridor), for they provide critical habitat for salmon production.

- The hypothetical mine scenario is the foundation for the assessment and reviewers recommend that EPA provide additional rationale for the scenarios assessed. Consider adopting a broader range of mine scenarios, especially smaller mine sizes, than the ones presented in the report.

- Incorporate mitigation measures (e.g., minimization, compensation, reclamation) from Appendix I into the document's mine scenarios discussion as they influence the range of mining impacts. Expand the discussion on the use of "best" management practices, because only "best" practice likely would be appropriate for a mine developed in the Bristol Bay watershed; anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself, without appropriate operational management controls, can always mitigate risk.

- Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, most likely will be necessary. Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity."

- Explain why the assessment's scope for wildlife and humans was limited to fish-mediated impacts. Reviewing effects beyond fish-mediated ones could improve the assessment because the potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts. Similarly, explain why fish-mediated effects on humans were limited to Alaska Native cultures.

- Strengthen the assessment with additional information to characterize the interconnectedness of groundwater and surface water and its importance to fish habitat in the watersheds. This discussion should consider seasonality (e.g., wet vs. dry summers or years) and how global climate change could influence hydrologic processes over the long term, which could pose challenges in distinguishing between impacts of climate change and mining impacts on the hydrology and salmonid ecosystem.

- The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community.

Further, primary and secondary production, including nutrient flux, was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other resident fishes, would provide additional context to this assessment of mine-related impacts.

- Explain how contaminants/metals of concern were selected. Include additional metals and their toxicities, as well as anticipated contaminant mixtures, in potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in this assessment.

- Provide consistent levels of detail for the different scenarios and stressors. For example, the document devotes 36 pages to catastrophic tailings storage facility failure, while sections on potential risks from pipeline, water treatment, and road/culvert failures are brief. The risks associated with potential spills from "day-to-day" operations deserve more attention in the assessment.

- Balance the level of detail between the text presented in the document and the useful information contained in the appendices. The appendices contain detailed and valuable information (roads, pipelines, mitigation, etc.) that should be summarized and incorporated in the document.

Following the meeting, peer reviewers were given additional time to complete their individual written reviews, which were submitted to Versar upon completion. These final written comments are contained in Section III of this report and fall into three categories: general impressions, responses to Charge Questions, and specific observations. Written peer review comments, as well as comments submitted to the docket by members of the public, will be considered by EPA as it works to revise the draft assessment document.

I. INTRODUCTION

I.1. Draft Assessment Background

In February 2011, EPA's National Center for Environmental Assessment (NCEA) announced a scientific assessment of Alaska's Bristol Bay watershed to understand and examine how future large-scale mining development projects may affect water quality, habitat, and salmon fisheries in the Bristol Bay watershed, which is home of one of the largest salmon populations in the world. On May 18, 2012, EPA released its draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*. The assessment focuses primarily on the Nushagak and Kvichak river drainages, as they are the primary areas in the watershed open to large-scale development.

Following the release of the draft assessment, EPA held a public comment period, which allowed members of the public to submit comments on the assessment. More than 200,000 public comments were submitted to EPA's docket and a summary of these public comments was developed by EPA and is included in Appendix A.

I.2. Peer Review Process

Versar, an independent contractor, was tasked by EPA with assembling 12 experts to conduct an external peer review of EPA's draft assessment. The peer review process provides a documented, independent, and critical review of the draft assessment, and its purpose is to identify any problems, errors, or necessary improvements to the report prior to being published or otherwise released as a final document. In assembling these peer reviewers and coordinating the peer review, Versar was charged with evaluating the qualifications of peer review candidates, conducting a thorough conflict of interest (COI) screening process, independently selecting the 12 peer reviewers, distributing review materials, managing the written peer review period, organizing and hosting the public peer review meeting in Anchorage, Alaska, and developing a final peer review report.

The peer reviewer selection process was initiated with a public nomination period, during which members of the public were invited to nominate candidate reviewers with expertise in the following scientific fields relevant to sections of EPA's draft assessment: (1) metals mining; (2) salmon fisheries biology; (3) surface; subsurface, or watershed hydrology; (4) aquatic ecology; (5) biogeochemistry; (6) seismology; (7) ecotoxicology; (8) wildlife ecology; and (9) indigenous Alaskan cultures. In addition to publically-nominated candidates, Versar independently identified a number of candidates in relevant fields of expertise. In total, Versar evaluated approximately 100 candidate reviewers, including all publically-nominated candidates, as well as those identified through independent research. Versar's in-depth and multi-staged evaluation of qualifications was based on each candidate's biosketch, curriculum vitae (CV), and publications.

In addition to the evaluation of candidates' expertise, Versar conducted a thorough COI screening of candidate peer reviewers. Each candidate reviewer was required to complete a series of screening questions to help determine if they were involved with any work and/or organizations that might create a real or perceived COI. Following this initial screening process, the final 12 peer reviewers underwent two additional COI certifications ahead of and at the public peer review meeting.

Prior to narrowing down the pool of candidate reviewers, Versar carefully considered the results of the qualification and COI reviews and following approximately six weeks of candidate evaluations, Versar independently selected the final 12 experts and proposed them to EPA for consent. In addition, Versar selected Dr. Roy Stein as Chair of the peer review meeting due to his expertise in salmonid fisheries biology and aquatic ecology, as well as his strong record of chairing and participating in national scientific meetings and workshops. The full list of 12 peer reviewers who participated in this review is provided below; in addition, each reviewer's biographical sketch is included in Appendix B.

Following the selection process, Versar distributed EPA's full draft assessment (Volumes I-III) and 14 Charge Questions (see Section I.4) to the peer reviewers. The peer reviewers were charged with evaluating the quality of the science included in EPA's draft assessment by reviewing the draft assessment and responding to these Charge Questions. Peer reviewers were not charged with making any regulatory recommendations, commenting on any regulatory or policy implications of EPA's role or mining development in the region, or reaching consensus in either their written comments or public deliberations. Additionally, peer reviewers were provided with a summary of public comments and given access to public comments submitted during the draft document's public comment period ahead the public peer review meeting, but were not asked to evaluate or respond to documents submitted to the docket.

Versar managed the pre-meeting peer review period, which provided the peer reviewers approximately two months to evaluate the draft assessment (Volumes I-III) and complete their written reviews. Following the draft Charge Questions' public comment and revision period, peer reviewers received the final Charge Questions during the week of July 13th, 2012. Versar collected and compiled each peer reviewer's draft comments and distributed them to the peer reviewers and EPA to prepare for the public peer review meeting. These preliminary responses to the Charge Questions formed the basis of reviewer discussions on Day 2 of the public meeting.

Peer Reviewers:

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Steve Buckley, M.S., CPG
WHPacific

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Washington State University

Gordon H. Reeves, Ph.D.
USDA Pacific Northwest Research Station

Charles Wesley Slaughter, Ph.D.
University of Idaho

John D. Stednick, Ph.D.
Colorado State University

Roy A. Stein, Ph.D. (Peer Review Chair)
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Oregon State University

Dirk van Zyl, Ph.D., P.E.
University of British Columbia

Phyllis K. Weber Scannell, Ph.D.
Scannell Scientific Services

Paul Whitney, Ph.D.
Independent Consultant

I.3. Peer Review Meeting

On August 7th, 8th, and 9th 2012, Versar convened a peer review meeting in Anchorage, Alaska. This meeting was held to conduct the scientific peer review of EPA's draft assessment and to provide members of the public with an opportunity to participate by either observing or providing oral comments to peer reviewers on Day 1 and observing peer reviewer deliberations on Day 2. The meeting followed both the assessment's public comment period, during which members of the public were able to submit written comments, and the pre-meeting written peer review period, during which the 12 selected peer reviewers read EPA's draft assessment and provided preliminary comments in response to Charge Questions.

Versar managed the pre-meeting registration period, which allowed members of the public to register to attend Days 1 and 2 as observers, as well as to make oral comments during Day 1's public comment session. Members of the public were able to register online, via Versar's registration website, as well as by telephone, email, or U.S. mail. Ahead of the meeting, Versar informed registered public speakers of their approximate speaking times and provided all registered attendees with pre-meeting handouts. On Days 1 and 2, approximately 220 members of the public attended the peer review meeting, with 95 of those attendees providing oral comments to the peer reviewers on Day 1. Please see Appendix C for the Agenda and Appendix D for a list of public attendees and speakers.

This three-day peer review meeting was organized as follows, with Days 1 and 2 being open to members of the public for observation:

- Day 1 of the meeting (Tuesday, August 7th) was dedicated to peer reviewers hearing oral comments from registered speakers. All speakers who pre-registered were provided the opportunity to share oral comments, which were limited to three minutes per speaker. The speaker schedule was set by Versar, and the order was determined by each registrant's self-selected comment category, which appeared on the online registration form. The order of comment categories at the meeting followed the order of their appearance on the online registration form (mine scenario & operational modes, potential failures and probabilities, hydrology, potential effects on Alaska Native culture, potential effects on fish, potential effects on wildlife; and other issues). Within each comment category, the order of speakers was determined by the date of registration, with those registering earliest speaking first. Speakers who were present but missed their speaking slot were provided time at the end of the speaking schedule to provide their comments. Approximately 95 members of the public shared oral comments with peer reviewers, related to assessment topics such as mining scenarios, effects on Native Alaskan culture, effects on salmonid fish, and other areas. Robert Wheeler of Triangle Associates served as the Day 1 Facilitator, managing the public comment session. Day 1 was webcast live to allow those who could not attend to observe.

- Day 2 of the meeting (Wednesday, August 8th), was dedicated to peer reviewer deliberations, which focused on responses to EPA's Charge Questions. Peer reviewers discussed all 14 Charge Questions, as well as their general impressions of the draft document, in front of an audience of public observers. Day 2 was also webcast live to allow those who could not attend to observe.

- Day 3 (Thursday, August 9th) was a closed session to allow peer reviewers to document and summarize their major recommendations, after considering the public comments and deliberations of Days 1 and 2. This session was not open to members of the public for observation or speaking; however, the results of this documentation are provided below, in Section II.

As noted above, Day 3 of the meeting was a closed session for the peer reviewers to document and summarize major recommendations from their deliberations on Day 2, which are presented in Section II of this report. EPA authors observed the session but did not engage in discussion with the peer reviewers or contribute to the development of the summary recommendations. In three instances, the reviewers requested clarification from EPA to assist in understanding the context in which the draft document was developed and under which it will be used. Specifically, following preliminary reviewer discussion about the lack of clarity in the draft document's purpose, scope, and intended audience, the Chair requested that EPA provide clarification. EPA shared that the assessment was initiated following requests from Federally-recognized tribes and intended to help the Agency better understand the potential impacts of large-scale mining in Bristol Bay, as well as to inform and outline the range of decision options for the Agency scientists and decision makers. EPA clarified that such decision options include, but are not limited to, any possible action under Clean Water Act Section 404(c). EPA further explained that the document was primarily developed to meet the Agency's need for scientific information, that the assessment itself is not decisional, and that it will not be the only source of information to inform future decision making.

Based on EPA's clarification, the reviewers resumed documentation efforts, which led to another inquiry later in the day on whether the draft document should be interpreted as a framework, decision-support document, or a risk assessment. In response to a request from reviewers for additional clarification, EPA explained that the draft document is neither a decision document, nor a framework; it is an assessment to evaluate the potential impacts of large-scale mining on salmon in the Bristol Bay watersheds and to inform future decision making options. It was also explained that, as a risk assessment, it uses conceptual models to help organize and present the analysis of sources, pathways, receptors, and endpoints.

Prior to the conclusion of Day 3's documentation efforts, reviewers inquired into the future use and intended audience of the draft document. The Chair requested additional elaboration from the EPA authors and EPA reiterated that the assessment will inform the development of and outline the Agency's future decision making options, while also educating and focusing stakeholders by characterizing various stressors and potential risks. Reviewers considered such clarifications and incorporated further questions or concerns into the recommendation summary effort (Section II), as well as their final individual comments.

Following the public peer review meeting, peer reviewers were given additional time to complete their individual written reviews. These final written comments are contained in Section III of this report. Written peer review comments, as well as comments submitted to the EPA docket by members of the public, will be considered by EPA as it revises the draft assessment document.

I.4. Charge Questions

Please provide narrative responses to each of the 14 Charge Questions below.

1) The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

2) A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

3) EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?

4) Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?

5) Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?

6) Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?
7) Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

8) Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

9) Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

10) Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

11) Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?

12) Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?

13) Does the assessment identify and evaluate the uncertainties associated with the identified risks?

14) Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?

II. SUMMARY OF KEY RECOMMENDATIONS FROM PEER REVIEWERS

This section includes a summary of the major recommendations put forth by the peer reviewers regarding EPA's draft assessment. In developing these recommendations, peer reviewers provided input on three major areas of the assessment – scope, technical content, and editorial suggestions. Reviewers also identified research needs for EPA to consider. Please note that this summary does not reflect a consensus or group perspective, but was compiled from a discussion of individual peer reviewer recommendations. Additional details, including references cited, can be found in the reviewers' individual comments in Section III.

Scope of the Document:

- Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

- Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

- Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

- Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

Technical Content:

<u>Mine Scenario</u>

- Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

- Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

- Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls, can always mitigate risk.

- Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50th percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

- Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a "walk away" closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity" (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow "walk away" closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

- Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.) were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what "mitigation" already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

<u>Risks to Salmonid Fish</u>

- Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

- Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

- Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

- Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

- Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

- Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

<u>Wildlife</u>

- Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

- Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

<u>Human Cultures</u>

- Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska).

- As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

<u>Water Balance/Hydrology</u>

- Better characterize water resources and assess the potential effect of mine development on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses; (3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

- Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

- Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

- Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

<u>Geochemistry/Metals</u>

- Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

- Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

<u>Mitigation Measures</u>

- Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

- Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate response, long-term reclamation).

<u>Uncertainties and Limitations</u>

- Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

- Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

Editorial Suggestions:

- The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

- Revise the Executive Summary to more precisely reflect the findings in the document.

- The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

- Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

- Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

- Generate a standard operating protocol for significant figures and use it throughout the document.

- Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a non-human-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

- Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

Research Needs:

- What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

- Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

- What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

- What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

- What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

- What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow? Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

III. WRITTEN PEER REVIEW COMMENTS

III.1. General Impressions

David A. Atkins, M.S.

The Bristol Bay Watershed Assessment (the Assessment) presents a comprehensive overview of current conditions in the watershed and establishes the uniqueness and global importance of the area to global salmon ecology (e.g., the report states that nearly 50% of the global sockeye salmon population comes from Bristol Bay and nearly 50% of the salmon in Bristol Bay come from the Nushagak and Kvichak Rivers, which encompass nearly half of the watershed area). The report also describes in detail the importance of the fishery to Native Alaska cultures, the importance and uniqueness of subsistence activities, and the scale of the commercial fishery. Furthermore, the report also outlines the reliance of the local economy on the salmon fishery.

There is no question that a mine, especially of the type and magnitude analyzed in the Assessment, could have significant impacts and that if these impacts are not or cannot be properly managed and/or mitigated, the consequences could be profound. The Assessment presents a mining scenario based on preliminary documents prepared for the Pebble Project, which sets out a conventional approach for development of a very large mine that includes open-pit and block-cave underground mining methods and conventional waste rock and tailings management. Development of the mine as proposed would eliminate streams and wetlands in the project area permanently. The importance of this impact is not put in context of the watershed as a whole, so it is not possible to determine the magnitude of the risk to salmon. The Assessment also did not consider whether there are any methods that could effectively minimize, mitigate or compensate for these impacts.

The Assessment also focuses on the risk of failure of the tailings storage facility, a low probability, but high impact scenario. The Assessment further describes the potential for long-term acid and metals production from waste rock and the necessity for water treatment. Under the mining scenario as described, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities and perpetual water treatment could be necessary. In addition, failure is always a possibility, albeit a possibility that is difficult to quantify with any degree of certainty as explained in the Assessment. The Assessment also does not consider alternative engineering strategies (so called 'best practice' approaches) that could lessen the risk of failure and possibly the necessity for perpetual management and water treatment. As such, the report could be considered a screening level assessment that presents the likelihood of occurrence and corresponding consequences of failures under the presented development scenario, but does not describe the magnitude of risk to salmon.

Steve Buckley, M.S., CPG

The assessment attempts to evaluate the potential impacts of mining development in the Nushagak and Kvichak watersheds. The main deficiency in the assessment is that it uses only two hypothetical mine scenarios to bracket the potential impacts of mining activities on the ecological resources in the watershed. Both of these mine scenarios are larger than the 90th percentile of all porphyry copper deposits in the world. In order to properly assess the potential effects of mining activities, in the absence of any specific mining proposal, a minimum mine scenario on the order of the 50th percentile of worldwide porphyry copper deposits would be more appropriate. Three or four mine scenarios would allow for a broad range of analysis, and the reader would be able to put the potential impacts of mining development in wider perspective.

A large part of the assessment provides information related to catastrophic potential system failures such as tailings dam failures and pipeline ruptures. There is inadequate information on, and analysis of, potential mitigation measures at the early stages of mine development, which would attempt to reduce the impacts of mining activities on fish and water quality. The bulk of the document is dedicated to evaluating the impacts of tailings dam failure on aquatic resources and yet in Chapter 4, the assessment provides a probability of tailings dam failure at 1 in every 2,000 mine years.

The assessment identifies the interconnectivity of groundwater, surface water, and fish habitat as being a major component of the quality of the fishery in the watershed yet puts relatively little effort into the analysis of the detailed relationships between groundwater, surface water, water quality, and fish habitat, even though this is likely the most important factor in assessing the potential impacts of mining activities on the fisheries in the watershed.

Additional mine scenarios and a more detailed investigation of the geomorphology, surface, and groundwater hydrology and their relation to fish habitat would provide the reader with a more accurate and more useful scope of analysis.

Courtney Carothers, Ph.D.

Synopsis: EPA's draft document examines the potential impacts of large-scale mining development on the quality, quantity, and genetic diversity of salmonid fish species in the Nushagak River and Kvichak River watersheds of Bristol Bay, Alaska. To the extent that both wildlife and Alaska Native communities in the region depend upon salmonids, fish-mediated impacts to these other "endpoints of interest" are also explored. A hypothetical mining scenario, informed by current exploration, planning, and study in the Pebble deposit area, is described using minimum and maximum estimates for mine production and includes the construction of a transportation corridor to Cook Inlet. Even in the absence of any failures or accidents, construction and operation of such a mine would have significant impacts to salmonids in stream systems proximate to the mine footprint with some related impacts to wildlife and human communities. At least one or more accidents or failures are expected to occur over the long lifetime of the mine. Immediate and long-term severe impacts to salmonids are expected to occur with any significant failure, with relatedly pronounced impacts to wildlife and Alaska Native communities in the region. Multiple mines in the region would amplify these impacts.

General impressions: Overall, the main report is well-written and presents information in multiple ways, including: narrative, conceptual models, images, figures, and tables. The report synthesizes a large amount of information, much of which is described in detail in the report's appendices. The report highlights the unique characteristics of this watershed: incredibly productive and sustainable salmon fisheries, relatively little large-scale modification of the natural environment, and active subsistence-based indigenous cultures still occupying their homelands and many still using their Native language. Making central these features of the watershed, the tone of the report suggests that some negative impacts to salmonids, wildlife, and Alaska Native cultures are necessarily expected to accompany any large-scale mining development and operation in this region.

The document should provide a clear articulation of the scope of human impacts considered in this assessment. The main report considers only *fish-mediated* impacts to *Alaska Native cultures*. The restriction of scope to only fish-mediated impacts should be further clarified. A host of social, cultural, and economic impacts would accompany large-scale mining development in this region. These direct and indirect human impacts, both positive and negative, were the focus of many public comments on the EPA draft document, yet they fall outside of the scope of consideration in this report. If the narrowed scope of fish-mediated impacts is justified, these other impacts should be clearly identified as outside of the scope of this report. At times in the report (e.g., p. 5-77), these other impacts are superficially mentioned. Unless a full treatment of these impacts is included (including a presentation of a large literature explores these impacts internationally, e.g., Ballard and Banks 2003), this cursory discussion should be removed. If maintained, the narrow scope should be reiterated throughout the report to remind the reader that these larger human impacts are not considered.

The report should articulate more clearly why Alaska Native cultures are the only human groups included in the assessment of fish-mediated human impacts. The report notes: "because…Alaska Native cultures are intimately connected and dependent upon fish, …the culture and human welfare of indigenous peoples, as affected by changes in the fisheries are additional endpoints of the assessment" (ES-1-2). This suggests that the limitation of fish-mediated human considerations to Alaska Native cultures is not due to government-to-government relationship between tribes and the federal government, nor the special status afforded by environmental justice concerns, but rather because of their close connections to, and dependence on fish. Arguably, other human groups also have connections to fish and depend upon on salmon in this region in various ways, but are excluded from analysis of potential impact in this report. This comment is not meant to detract from the importance of the focus on Alaska Native cultures and the primarily indigenous communities in this region for assessing fish-related impacts. Rather, the comment is made to suggest the inclusion of a clear justification for this focus, or the broadening of scope to include other human groups who are also connected to, and dependent upon, salmon in this region (e.g., substantial information on the economic dimensions of salmon resources in this region is summarized in Appendix E, but little is presented in the main report). Additionally, the assessment of fish-mediated effects to Alaska Native cultures is primarily focused on subsistence fisheries. More discussion of the role of commercial engagements in salmon fisheries (e.g., commercial harvesting, processing, recreational fishing businesses and employment) in the watershed communities in this region would be helpful.

Dennis D. Dauble, Ph.D.

Overall, the main report and each of the accompanying appendices were well written. I was unable to identify major inaccuracies or bias in the material as presented. There were shortcomings in the main report, however. For example, some topics would benefit by being expanded (Sections 5.6 and 8.7), while others have more detail than appeared necessary (Section 6.1). The assessment effectively addressed three appropriate time periods: (1) operation, (2) post-closure, and (3) perpetuity. Potential effects are bounded by a minimum and maximum mine size, which is also appropriate. Inclusion of inference by analogy strengthened the conclusions reached in the assessment and helped validate results obtained from model predictions.

Most figures and tables were useful. The conceptual models and accompanying illustrations of potential habitat effects (Figs 3-2A and C) are important because they provide a view of complicated pathways and relationships among potential activities and environmental attributes.

However, these relationships are not revisited in any detail later in the document. I recommend discussing the conceptual models in more detail in the main report (Section 3.6) and summary section in Chapter 8.

The Integrated Risk Assessment (Chapter 8) did a creditable job of summarizing habitat losses and risks from mine operations. What is missing, however, are quantitative descriptions of habitat lost relative to total habitat available in the larger watershed and individual systems. Habitat loss should be further discussed in terms of salmonid life stage and productivity (i.e., not all stream miles are equal).

If anything, the conclusions could be strengthened. The summary of uncertainties and limitations (Section 8.5) dwells on things that "could not be quantified" due to lack of information, model limitations, or insufficient resources. Thus, this reader was left somewhat in limbo as to the potential magnitude of effects from mining activities. (Note that this "neutral voice" is carried throughout the Executive Summary). Many people might interpret such statements of uncertainty as no proven effect. My point is that probable environmental consequences of mining activities are much greater than this report alludes to, given that consequences <u>are likely</u>, even if their magnitude is "uncertain."

Section 8.7 is perhaps the most important section of the report. It should be comprehensive, i.e., cover all resources and be more quantitative. Missing from the summary were impacts on wildlife, human culture, resident fish, and other ecological resources. Essential details from Appendices A, C, E, F, and I, for example, could be synthesized and moved into the main report.

Gordon H. Reeves, Ph.D.

The purpose of the report is unclear, which makes it difficult to assess. The report focused on the potential impact of a hypothetical mine on salmon and salmon habitat in two watersheds in Bristol Bay, AK. However, it is not clear whether the analysis was intended to be a case study of the potential impacts of a hypothetical mine under the various scenarios presented or whether the intent was to develop a framework for assessing mining scenarios. These are two very different objectives, which makes it critical that the purpose be clearly stated in the beginning of the document so that reviewers and others understand the purpose of the document. There certainly was much confusion among members of the review panel and the people who commented on the report because of this.

I think that the credibility of the report could be improved substantially if the analyses were formalized and more clearly articulated and defined. The authors could consider using a decision support process, such as a Bayesian approach (see Marcot, B.G., J.D. Steventon, G.D. Sutherland, and R.K. McCann. 2006. Guidelines for developing and updating Bayesian belief networks applied to ecological modeling and conservation. Canadian Journal of Forest Research 36: 3063-3074). This would provide more transparency to any analysis and allow others to better understand how results and conclusions were derived. Also, it would identify critical relations that should be considered and provide insight about the consequences of not considering them. This will undoubtedly take additional time and effort, but I believe it would be well worthwhile. Examples of where such analysis has been done are in: (1) Armstrup et al. 2008. A Bayesian Network Modeling Approach to Forecasting the 21st Century Worldwide Status of Polar Bears. Pages 213-268. *in* E.T. DeWeaver et al., editors. Artic Sea Ice Decline: Observations, Projections, Mechanisms, and Implications. Geophysical Monograph 180. American Geophysical Union, Washington, D.C.; and (2) Lee, D.C. et al. 1997. Broadscale

Assessment of Aquatic Species and Habitats. Vol. III, Chapter 4. U.S. Forest Service, General Technical Report PNW-GTR-405. Portland, Oregon.

I thought one of the strongest aspects of the report were the conceptual diagrams of relations between the various aspects of the development and operation of a mine and the components of the ecosystem that influence salmon and their habitat (Chapter 3). These diagrams show the components of the ecosystem, the relation among them, and how mine impacts could potentially influence given parts of the ecosystem directly or indirectly as a result of cascading effects. They are a good first step in developing a decision support framework, as suggested in the previous paragraph. There was, however, little discussion about them in the text and it was not clear if or how they were used or considered in the analyses. The authors should, at the very least, clearly identify which parts of the networks were considered and why these particular avenues were pursued and others were not. This would provide additional insights into potential limitations of the analyses and results.

If this was a case study, the report appeared to have considered available literature and reports on all aspects of the mine, its operation and the parameters that could be affected by it. I am not familiar with this literature so it is not possible for me to comment on the adequacy of the literature and reports considered. Assumptions about the location and operation of the mine seemed reasonable and the authors clearly articulated limitations of available data and other information concerning the mine's location and operation. I found the consideration of the mine during the various phases of development and operation and the discussion about potential development of other mines in the area particularly insightful. Inclusion of experiences from other mining operations was also helpful in understanding the conclusions about potential impacts of the mine and its operation over time. Additionally, the consideration of the potential development of other mines in the area was particularly insightful and provided a good picture, albeit not in depth, of potential cumulative effects on aquatic resources in the Bristol Bay area.

Parts of the report on the ecology of fish and aquatic ecosystems, road, and culverts – topics that I am familiar with – were covered very well and the conclusions about potential impacts of the mine and its operation generally seemed justified. The authors presented available data and information on fish distribution and abundance relative to the presumed location of the various components of the mine operation. Their analyses were appropriate but rather cursory, which is not unexpected given the restrictions of time and available data. However, there are some additional considerations and analyses that could be done, which I think would improve the report. I identify these in answers to specific charge questions. Limitations of the results were readily acknowledged. However, as mentioned above, there are additional limitations that resulted from only considering selected potential avenues of impacts. These should be discussed in the revision.

The authors do a good job of summarizing the scientific literature on salmon ecosystems, roads, and culverts. Most of this is from studies in areas outside of Bristol Bay. Interpretations of the findings were accurate. However, there was no discussion about potential limitations on the application of the studies to the area being considered. For example, Furniss et al. (1991) deals with roads in forest and rangeland settings. These are very different environments than Bristol Bay, which suggests that road impacts will likely differ. Much attention is given to "headwater streams" and their ecological importance (p. 5-19 – 5-21). Headwater streams for the area of consideration need to be defined so that appropriateness of the application of the literature can be better judged.

A major component that is missing from the report is consideration of the potential impacts of climate change. Climate change is identified as a factor in the conceptual model of potential habitat and water quality effects associated with mine accidents and catastrophic failures (Fig. 3-2D). However, I believe that it is a key factor that will have influence in all aspects of the assessment, not just failures and natural disturbance events (Fig. 3-2C). It needs to be considered in other aspects, such as water quality and availability. Climate change should also be included in any analysis because it will be critical to build it into any monitoring program that is developed in order to be able to differentiate its impact on salmon and their habitat from potential impacts of the mine.

Charles Wesley Slaughter, Ph.D.

Provision of full-color versions of all figures would have been helpful to the reviewers.

The Assessment (Volume 1 – Main Report) provides a fairly comprehensive review of fisheries-driven issues, from the perspective of salmonids. Appendices (Volumes 2 and 3) are very informative. The high significance of the Bristol Bay watershed, specifically of the Nushagak and Kvichak river systems, for commercial fisheries on the global scale and for sport and subsistence fisheries at the regional and local scales, was appropriately described.

The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with less attention on "salmon-mediated" impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

Chapter 2 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region.

The "Water Management" section (4.3.7) seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…" do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen), would be planned for or actually managed adequately.

Perhaps I missed it, but I found no acknowledgment of the potential presence of or consequences of perennially frozen soils – permafrost – in the Bristol Bay watershed, or more specifically in the Pebble ore deposit locale or the proposed transportation corridor. Selkregg (1976), Fig. 136, shows soils of the Pebble locale as INT/2g, INT/1g – HYP, or SOU/2g-HYP – that is, well-drained gravelly soils (INT) or well-drained acidic soils (SOU) with interspersed peaty, poorly-drained shallow discontinuous permafrost. There is abundant literature on the influence of permafrost on engineered structures, roads, hydrology, etc. Even if the bulk of the terrain involved in the proposed Pebble mine, road and infrastructure project is founded on well-drained gravelly soils, any interspersed permafrost-underlain terrain can prove problematic in terms of landscape stability, potential erosion, and consequent structural, engineering, hydrologic and water quality issues. See Specific Observations for a few suggested references in.

While there is extensive discussion of a proposed transportation corridor, there was no mention of construction of a major airfield. A project of this magnitude would undoubtedly require development of a facility in close proximity to the mine(s) capable of handling C130 and commercial jet passenger and cargo traffic, at least to the 737 class, if not 747. I don't know what the footprint for such an airfield would be, but it would be substantial, and with requisite roads, fuel handling, etc., would be a major project in itself. This would seem to be a logical component of a comprehensive assessment of the potential Pebble project.

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure which would follow an initial mining project. A truly comprehensive analysis should incorporate full analysis of these aspects. This Assessment is thus inadequate in terms of considering potential broader consequences for the Bristol Bay watershed system.

John D. Stednick, Ph.D.

The purpose of the document is not clearly stated in either the Executive Summary or the Introduction. Need to specifically identify the document as an environmental risk assessment. There is a misconception that it is a CWA Section 404(c) review, rather than an environmental risk assessment. The document should have the utility to inform future users of the risk to the watershed resources from mining activities in the watershed. The assessment can be used by others for decision making purposes, and includes current and appropriate methodologies for all identified stressors, such that study results can be duplicated. And all stressors are evaluated to a similar level of detail.

The document characterizes the potential environmental effects of an open pit mine over a copper porphyry complex in southwest Alaska using a hypothetical mine design based on similar ore deposits and mine complexes elsewhere. Proposed mine activity has been identified by the Pebble Limited Partnership though Northern Minerals Dynasty and should be cited to improve applicability of the risk assessment. Furthermore, a wider range of mining scenarios should be developed and analyzed for environmental risk assessment. Environmental consequences were estimated by the environmental risk assessment model approach for both 'no-failure' and 'failure' scenarios. The Executive Summary concluded that the effects of mine development resulted in significant salmon habitat losses. Potential effects on other aquatic species were not identified. The assessment evaluated environmental risks under the development and closure scenarios using large catastrophic events and did not include smaller, yet more frequent excursions or system failures. Nor did the assessment look at the full range of mine development scenarios, specifically what are the risks associated with a smaller underground operation?

The conclusions of the Executive Summary are strongly worded (e.g., pages ES 13 to 24), yet the uncertainties presented later in the report make the strong conclusions tenuous. An expanded discussion of uncertainties and limitations may temper those 'conclusions.'

Site characterization/description of current conditions is too brief. More information is needed for a full site characterization. Any reader unfamiliar with the setting would not fully understand the physical, biological, or ecological inventories and linkages in the study area. The risk assessment of failure and no failure are covered in Chapters 5 and 6 with varying levels of detail and substantiation of conclusions. Statements like "salmon is important in the human diet, thus a salmon loss affects human health" seem like a weak argument, especially when additional information in the appendix suggests a larger effect.

The Pebble Limited Partnership has a large environmental baseline database (EBD), but does not appear to be cited or used. Justification for the inclusion or exclusion of these data should be made. Reference is often made to various data, but these data were not presented.

Review and revise the water balance section, which would include: 1) generating a diagram or conceptual figure similar to page 3-7 to illustrate the potential effects of mine construction and operation on surface and groundwater hydrology; 2) developing a quantitative water balance for surface and groundwater resources; 3) incorporating seasonality (especially assessing the role of frozen soil); 4) identifying hydrologic processes and their associated values (e.g., mm/yr) for each component of the water balance in time and space, and then incorporating into a landscape characterization; 5) demonstrating the interconnectedness of groundwater, surface water, and the importance to fish habitat and stream productivity; 6) evaluating the influence of global climate change on these hydrologic processes and rates; and 7) using this characterization demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development and closure scenarios.

One common theme that emerged from the public comment session during the peer review meeting in Anchorage, AK was the questioning of the document timing, from draft release to the public comment period to the unannounced completion of a final document. These concerns should be addressed in the new document.

Roy A. Stein, Ph.D.

Accuracy of Presentation. Overall, I was pleased with the accuracy of the presentation. Typically, peer-reviewed citations to the scientific literature were cited as supportive documentation for most all of the factual information (though the well-developed appendices, e.g., Appendix E: Economics; Appendix I: Mitigation, could be used to far better advantage, see below). Unfortunately, in the main report, many data are missing, especially with regard to salmonid populations, their diversity (both across species wand within species across populations), their relative population sizes, their distribution across the watershed, their vital rates (i.e., recruitment, growth, and survival across life stages), and to what extent the Pebble Mine and its associated activities will reduce these populations (for there is no question they will indeed be reduced through both the mine footprint and all allied operations in the drainage), both through impacts on individual populations and the overall production of salmonids (and other fishes) in the Bristol Bay watershed. Whereas I am relatively confident about accuracy of the fisheries information included, I cannot comment in detail regarding the accuracy of the mining information or impacts on the Native Alaskan cultures (though the impact of the mine on this culture was confined to fish-mediated effects). That a Native Alaskan culture 4,000 years old is in jeopardy bothers me greatly; might this complete subsistence way of life in the Bristol Bay watershed be eliminated with the exploitation of the copper via open-pit mining? In turn, what impacts might there be on subsistence users, other than Native Alaskans? Even though these sections seemed reasonably well presented (with caveats above) and appropriately supported with citations, they do lie beyond my expertise.

My concerns about the document revolve around issues that were not considered, i.e., Global Climate Change, "In Perpetuity" issues, groundwater-surface water exchange issues (owing to missing information), impacts of Routine Mine Operations in a more realistic setting, the seemingly undue influence on a failure of the Tailings Storage Facility, and other somewhat more minor issues (see comments below). With any revision, the authors should include this information by eliminating redundancy (see below), thereby not increasing document length.

Clarity of Presentation. Generally speaking, I believe that the writing was intelligent, reasonably insightful, and, more specifically, on task. One significant criticism with regard to the presentation revolves around the organization of the document. As detailed below, the organizational scheme lent itself to redundancy, from the Introduction through the various chapters to the Integrated Risks Characterization chapter. Owing to this redundancy, the report is likely too long by about 20% and any revision and shortening should serve to improve its impact on readers.

The conceptual block and arrow diagrams (pages 3-7 to 3-11) were quite instructive. They nicely demonstrate the interactions that occur within this mining scenario. The main report would be much improved if text were to review this set of interactions. Clearly, a tremendous amount of time, effort, and thought went into generating these diagrams and it is indeed a true shortcoming of the main report that essentially no text was spent stepping through these diagrams.

Soundness of Conclusions. The conclusions were well supported, where there were published data to support them. Many statements that could be interpreted as conclusions were often more qualitative than desirable in a review document such as this one, owing to the lack of information (percent of salmonids lost owing to routine mine operations, impacts of mining and the transportation corridor on wetlands, extent of groundwater-surface water disruptions, just to name a few). Consequently, the soundness of the conclusions are somewhat compromised by a lack of information.

In addition, what would aid readers is a succinct statement of the purpose (risk assessment?, impact on water quality and then through to fishes and beyond?, etc.) and scope (relatively narrow impact of the mine on salmonids and ripple effects out from there) of the document early in the initial chapter. In so doing, both reviewers and readers will be informed as to the direction of the document and thus better informed as they move through the document.

Finally, a portion of the public testimony complained about the process, specifically about the time allowed for document review, the data reviewed, the validity of the hypothetical mine, etc. Though I found most all comments to be somewhat disingenuous, I still would offer the following advice: Provide a section upfront that deals with process issues surrounding the review, i.e., explaining the constraints under which EPA was operating; without a section like this, complaints, such as those described above (coming from just one segment of the public), will go unanswered.

William A. Stubblefield, Ph.D.

The document, "An Assessment Of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," is a well-written, comprehensive document that employs a risk assessment-type approach to an *a priori* evaluation of potential environmental effects on the ecosystem and potential receptor species (e.g., salmon) that may be affected by a potential copper mine located in the Bristol Bay area of Alaska. This document is somewhat unique, in that no actual mine has been proposed at the location and few site- or project-specific data are available. Therefore, no specific information about development plans and potential operational and closure activities associated with the mine are available. Rather, the authors have attempted to develop a hypothetical mine and attempted to assess possible environmental effects associated with mine development, operation, and closure. Although interesting, the potential reality of the assessment is somewhat questionable. It is also unclear why EPA undertook this evaluation, given that a more realistic assessment could probably have been conducted once an actual mine was proposed and greater detail about operational parameters available. The approach taken in the document attempted to be comprehensive and evaluated a variety of scenarios that may affect aquatic resources in the Bristol Bay region. Given the importance of salmon populations in the area, both from a financial and societal perspective, it is important that a comprehensive evaluation of potential environmental effects associated with mine development and operations be conducted. The authors have attempted to conduct such a comprehensive evaluation and have attempted to quantify (to the extent possible) the probability of adverse effects occurring. Implementation of this approach is proper, and with the correct data, can provide a comprehensive evaluation of potential environmental effects. Unfortunately, because of the hypothetical nature of the approach employed, the uncertainty associated with the assessment, and therefore the utility of the assessment, is questionable.

A variety of uncertainties and data needs were identified as a result of this effort and this alone may provide sufficient value to justify the document and approach. For example, the authors note that there is not an abundance of chronic toxicity data considered in deriving the EPA's ambient water quality criteria for copper and that there is an uncertainty associated with whether the biotic ligand model (BLM) adequately protects species of concern in Bristol Bay. It would seem appropriate for EPA (perhaps in concert with industry) to develop the data to improve our understanding of copper toxicity and to ensure that regulatory standards are, in fact, appropriate for their intended use. A substantial body of data evaluating copper chronic toxicity has been developed by the copper industry as a result of regulatory requirements driven by the European REACH regulations. It may be beneficial for EPA to examine these data, thus resulting in a reduction in any uncertainty associated with the evaluation of environmentally acceptable metals concentrations. It should also be noted that similar datasets and biotic ligand models exist for number of other metals that may be of concern at the Bristol Bay site.

One suggestion that would improve the document is that EPA should include a basic description of the risk assessment process and the relationship between the risk assessor and the risk manager, i.e., the decision maker. They must include a discussion of why the assessment is being conducted, the decisions that will be informed, and what information they need from the risk assessor.

Taken from the USEPA's Guidelines for Ecological Risk Assessment (EPA630/R-95/002F; April 1998). Note 2nd sentence re: the role of the risk manager.

> *"2.1. THE ROLES OF RISK MANAGERS, RISK ASSESSORS, AND INTERESTED PARTIES IN PLANNING*
>
> *During the planning dialogue, risk managers and risk assessors each bring important perspective to the table.* ***Risk managers, charged with protecting human health and the environment, help ensure that risk assessments provide information relevant to their decisions by describing why the risk assessment is needed, what decisions it will influence, and what they want to receive from the risk assessor.*** *It is also helpful for*

managers to consider and communicate problems they have encountered in the past when trying to use risk assessments for decision making.

In turn, risk assessors ensure that scientific information is effectively used to address ecological and management concerns. Risk assessors describe what they can provide to the risk manager, where problems are likely to occur, and where uncertainty may be problematic. In addition, risk assessors may provide insights to risk managers about alternative management options likely to achieve stated goals because the options are ecologically grounded."

Dirk van Zyl, Ph.D., P.E.

Planning and designing a large mine, and especially one in a sensitive environmental setting such as Bristol Bay, involves many iterations before a design evolves that is provided for further public considerations. The EPA elected to use a design, developed for Northern Dynasty Minerals Ltd. in a preliminary assessment prepared following the guidance of National Instrument (NI) 43-101, as the basis for extensive evaluations in their risk assessment. The resulting risk assessment can be at best characterized as preliminary, screening level, or conceptual. There are both technical and process issues that must be addressed before this risk assessment can be considered complete or of sufficient credibility to be the basis for a better understanding of the impacts of mining in the Bristol Bay watershed.

There are a number of items that require specific attention prior to finalizing the report. While my comments below provide further details, from a global perspective the following aspects must be addressed:

- A better sense about the range of impacts from a mining project that use not only different technologies but also different lay-out options in its development than that assumed in the EPA Assessment;
- More attention to the use of appropriate order of magnitude numbers reflective of the quality of data, e.g. less accuracy is obtained when 1:62,500 scale vs. 1:12,500 scale maps are used;
- Correction of errors associated with misquoting and incorrect use of information in the literature; and
- A critical review and rewrite of the Executive Summary to reflect the tone, terminology, information sources and results of the main body of the report. One example of an error and one of inconsistent terminology are:
    - Page ES-10: "Thus, the mine draws on plans published by the Pebble Limited Partnership (PLP)", this is incorrect as the plans that were used were prepared for Northern Dynasty Minerals Ltd.
    - Page ES-10: "…our scenario reflects the general characteristics of mineral deposits in the watershed, contemporary mining technologies and best practices…" The main body of the report emphasizes on a number of occasions (such as Page 4-1, 4-17) that "Our mine scenario represents current good, but not necessarily best, mining practices".

My comments contained above and below are based on a single review of the report, i.e. contractual time constraints were such that I could not afford a second review of the report. It is therefore possible that there are other errors remaining in the report that I did not observe in my review. It is therefore recommended that after making these corrections and edits that EPA subject the report again to a rigorous independent review.

Phyllis K. Weber Scannell, Ph.D.

My comments on EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* follow a three-day peer review meeting in Anchorage, AK. On the first day of the meeting, the Peer Review Team heard testimony on the importance of the resources in the potentially affected area and on possible effects of mineral development on the fish and wildlife resources and on local residents. The issues of mineral development are complex, particularly with respect to protecting the environment and the interests of local residents. I understand and appreciate the complexity of these issues; however, the charge of the Peer Review Team is to review EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* and offer suggestions to strengthen the report. My comments, included below, are focused on the accuracy and thoroughness of the draft document.

The document "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" and the accompanying appendices provide an in-depth and thoroughly documented description of the environment and resources of the areas under consideration for mineral development, although not in the entire Bristol Bay region. Appendices A and B are particularly thorough in describing the salmon and non-salmon fishes in the region; the discussion of species specific fish sensitivities to certain toxicants adds important information for future consideration of project development.

The assumptions for developing and operating large porphyry copper mine may not be aligned with features of a future mining project. Too much emphasis was placed on effects of catastrophic failures, such as failure of a tailings dam or pipeline, and too little emphasis on the need to identify and control seepage water, run-off from PAG (potentially acid generating) and NAG (not acid generating) waste rock areas, and water treatment.

The document discussed effects of dewatering on suppressing stream flows and groundwater inputs but did not consider effects of the discharge of treated wastewater. The section on hydrology illustrates the need for more complete hydrologic information before any project development. The need for bypassing all clean water sources around a development site should be addressed.

The cultural characterizations and effects on human populations from large mine development are outside my area of expertise; therefore, I cannot comment on the adequacy of the information.

As stated in my response to charge questions, I believe that the two most important questions for mineral development in this region are: can a mine be designed and operated for future closure? and, if not, is it acceptable to develop a large porphyry copper mine in a region of high value salmon habitat that will essentially require perpetual treatment? These two questions must be addressed when considering protection of the fish, wildlife, and human resources of the region.

Paul Whitney, Ph.D.

Response (with a wildlife perspective) – The main document is fish centric and it should be, given the importance of salmon in the Bristol Bay ecosystem. Wildlife (aquatic, wetland and upland species) and terrestrial resources related to potential mine and haul road impacts are glossed over. The summary write ups for several species of wildlife (Appendix C) are very good regarding natural history and some potential impacts. Information in Appendix C tends to focus on the proposed mine site and less on the proposed haul road and game management units in the Kenai Mountains.

A variety of authors have obviously contributed to the documents and it appears that the direction given to them or their interpretation of goal statements varies. For example, if one of the goals of the assessment is to evaluate the risk to wildlife due to risk to fish (Executive Summary, page 1, last para) it's not clear why so much verbiage in Appendix C (wildlife) is devoted to species such as caribou that are not closely associated with fish. Information in Appendix C could be used to assess direct impacts if the scope of the assessment is expanded. For example, if the goal is to assess the impact of potential mining on the ecosystem (see Executive Summary page 1, para 1), the information on caribou in Appendix C is more relevant. The apparent diversity of goal statements cited in the main assessment gives mixed messages regarding the clarity of the presentation (see more detailed discussion below).

The charge question related to wildlife asks for an evaluation of the risk to wildlife due to the risk to fish. If the risk to fish can not be quantified because there is little or no demographic information, then any evaluation of risk to wildlife can't be quantified and must be qualitative. Merely stating that a qualitative increased risk for fish will also result in a qualitative increased risk for wildlife is not adequate. I am not satisfied with such an obvious and general conclusion. I do not understand why the scope of the main document is limited to an indirect evaluation of fish-caused risk to wildlife. The following responses to charge questions leans more toward an ecosystem evaluation that includes, not only risk of fish to wildlife, but also risk of direct wildlife and vegetation loss to fish and other direct risks to wildlife, such as noise and human presence.

III.2. Responses to Charge Questions

Question 1. The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

David A. Atkins, M.S.

Based on my general understanding of the watersheds, I consider the general background information presented in the Assessment accurate and sufficiently complete for the endpoints of this watershed assessment in the following areas:

- General view of Pacific salmon populations
- General view of resident (non-anadromous) fish
- Wildlife populations
- Native cultures

The Assessment also describes the current economics of the watershed, including commercial and sport fishing and subsistence activities.

Additionally, the report highlights several general aspects of the area that make the fishery unique in both its abundance and diversity:

- The unique hydrology of the area (strong groundwater and surface water interaction) that contributes to stable flows and temperatures favorable for salmon reproduction.
- The importance of anadromous fish in transferring marine-derived nutrients to upland areas and thus providing nutrients to areas that would naturally be nutrient poor.
- The lack of roads and infrastructure that make the area unique as one of the few intact ecosystems remaining in the world, and possibly unique for this type of fishery.

It would be helpful in the background section to better describe the uniqueness of the Bristol Bay watershed ecosystem in the Pacific Northwest. This could include a description of other similar ecosystems in the region that have undergone development and documentation of any changes in fish populations associated with this development. The Assessment does mention the Fraser River as an analogue, but the scale of development in this watershed, and even the success of the salmon fishery, seems to be a point of contention, with some saying mining and fish coexist, and other saying the impacts are severe.

It would also be helpful to better explain fish resources in the proposed project area in comparison to other areas within the watershed. I understand some of the necessary data may not be available for the project area. It would be helpful to know, however, if the habitat in the project area is typical, exceptional, or inferior to that in other areas of the watershed.

Regarding geological resources, the report describes the Pebble deposit and five other mineral deposits in the Nushagak and Kvichak watersheds. It would be helpful to know if there are other mineral resources or oil and gas resources in the Bristol Bay watershed as a whole that could also be exploited. It would also be helpful to describe the portion of the watershed that is off-limits to development due to park and protected area status vs. those lands that are open to mineral development.

Steve Buckley, M.S., CPG

The background information presented in the characterization of the ecologic, hydrologic, and geologic resources is overly broad in scope. Specifically, the descriptions of the relationship between landforms, streams, and surface water and the interaction with groundwater are mentioned as very important to fish in the watersheds, yet there is insufficient detail to assess these interactions and consequently, the characterization of these resources is weak. There is more detailed information available in the Environmental Baseline Document (EBD) regarding the relation between landforms, streams, groundwater, and fish habitat in the watershed.

Courtney Carothers, Ph.D.

The background information presented on the ecological and geological resources of the Nushagak and Kvichak watersheds appears to be appropriate and accurate. The report notes that there is a lack of quantitative data on salmonid populations in this region, a lack of a full identification and characterization of salmon presence, spawning, and rearing areas, and a lack of detailed understanding of how local stream and river system features (e.g., temperature, habitat structure, predator-prey relationships, limiting factors) affect salmonid production in the region. Further, climate change is noted to be affecting local conditions. These unknowns are important to stress throughout the report.

The cultural characterization presented in Appendix D presents detailed information on historical and contemporary Yup'ik and Dena'ina communities of this region, stressing the centrality of salmon and subsistence in these cultures. This assessment benefits from the time-depth of relationships developed by Boraas and Knott. Overall, this section of the report is based on standard ethnographic methods, although the research design and analysis could be explained in more detail (and described in a separate methods section). The "voices of the people" sections are helpful to present directly the perspectives given by local people. These quotes reveal the complexity of subsistence and contemporary village concerns in this region. At times, the cultural assessment can minimize this complexity.

As detailed in the specific comments below, potential risks and impacts to subsistence are underestimated and at times framed in the report as primarily ones of physical health and economic factors. As described in Appendix D, harvesting, processing, sharing, and consuming wild foods are central to social, cultural, spiritual, psychological, and emotional well-being in Yup'ik and Dena'ina cultures. The subsistence lifestyle is considered central to the health of the people and communities of this region. This is particularly important to note for indigenous communities who continue to cope with the legacies of colonialism. This point is made in Appendix D (but at times could also be strengthened there, as suggested below), and is articulated in some of the quoted interview material.

Recent data on subsistence harvests, use areas, and local context collected for the PLP Environmental Baseline Document (as well as evaluation and discussion of such data, e.g., Langdon et al. 2006) and by the Alaska Department of Fish and Game (e.g., Fall et al. 2012) would be a useful addition to the cultural characterization. Other studies of local traditional ecological knowledge (e.g., Kenner 2005) may help to supplement the assessment of the abundance and distribution of fish species in this region, or to supply information on other less-studied freshwater fishes. Recent research on the contemporary salmon-based livelihoods of the region (e.g., Holen 2011, 2009a, and 2009b; Hebert 2008; Donkersloot 2005) would also be helpful to include. An inclusion of case studies of salmon-based cultures that have suffered depletions of their resource base would add to the presentation of likely fish-mediated impacts to culture (e.g., Colombi and Brooks 2012).

Appendix E also characterized the economic baseline of the region. Why is this dimension not asked about here?

Dennis D. Dauble, Ph.D.

As noted in the approach, characterization of and risk to ecological resources emphasized salmon and other important sport and commercial fish species. Consequently, the description of non-salmonid species generally lacked estimates of population size, except for sport and subsistence catch statistics. There was a long list of other resident fish in Appendix A, but their role in the Bristol Bay watershed (including the Nushagak River and Kvichak River watersheds) is not described in any detail there or in the main report. Available data on known or perceived ecological interactions among salmonid and resident fish should be included in the assessment.

Another limitation to the salmon-centric assessment is that risk assessment endpoints, described in Chapter 3 of the main report, do not address other aquatic ecological resources. Consequently, while there was acknowledgment of ecological dependencies among salmon, other fishes, and land mammals, very little information was provided on primary and secondary production processes of aquatic communities. For example, the relative importance of marine-derived nutrients (MDN) in the form of salmon eggs and carcasses is discussed, but there is only brief mention of aquatic insects in the diet salmonid species. What nutrient levels occur in these stream systems with and without MDN?

A description of major groups of aquatic invertebrates in terms of biomass and seasonal abundance should be included in the main report. Further, aquatic and terrestrial food webs and linkages need more embellishment. One approach might be to add narrative text with the conceptual model discussion, including descriptions of community structure, function, and biomass.

More detail on river and lake limnology would be helpful. For example, the hydrology of the watershed is mainly limited to a brief discussion of salmonid habitats. The geology of the basin emphasizes geology of mining areas and mineral processes. A more landscape-based description is warranted given the importance of geology to surface water processes and groundwater movement. The report would benefit from having a summary table listing lake size/volume and river length/discharge for watersheds potentially affected (and not affected) by mining activities.

Also missing were specific habitat requirements for rearing of juvenile salmon. A brief description of where pink and chum salmon spawn and rear in the Bristol Bay watershed relative to other salmon species should be included in the main report. There was nothing in Appendix A on where coho, pink, and chum salmon reside within the Bristol Bay watershed.

Each appendix has a wealth of supporting information and could serve as a stand-alone document. However, having to work back-and-forth between the main report and appendices to interpret critical aspects of the assessment presents a challenge. Don't assume the average reader will read (and interpret) these appendices. To help remedy, the authors of the main report should strive to directly cite relevant information (and/or a specific appendix) that supports their conclusions.

Gordon H. Reeves, Ph.D.

The assessment, which included the report and appendices, was comprehensive and thorough regarding the ecological resources of the Nushagak and Kvichak watersheds. The best available data on fish numbers and distribution (Alaska Dept. of Fish and Game's aerial escapement counts, records from the Anadromous Waters Catalog and Alaska Freshwater Fish Inventory, and the Environmental Baseline Document of the Pebble Limited Partnership (2011)) were used for the assessment. These data formed the foundation for much of the assessment on potential impacts to anadromous salmonids and their freshwater habitat in these watersheds and their characterization appeared to be accurate. The authors also appeared to have thoroughly identified and considered all of the appropriate literature.

I am not familiar with data available for the other resources and am thus unable to assess their appropriateness.

Charles Wesley Slaughter, Ph.D.

If only Volume 1 (the Main Report) is considered, the characterization of some aspects of the Nushagak and Kvichak watersheds would have to be termed cursory. Chapter 2, Volume 1 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region. Similarly, Volume 1 provides a relatively superficial discussion of non-fish wildlife concerns, or human/cultural concerns

By contrast, the information provided in Appendices A-H appears to be comprehensive and complete for each subject field. (Appendix I appears to be a general "template" summary, not tailored to the Bristol Bay watershed environment).

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure, which would follow an initial mining project. A truly comprehensive analysis should incorporate a full analysis of these aspects.

John D. Stednick, Ph.D.

The site characterization needs to be expanded. The report needs to better characterize the physical setting. There are a variety of data sources that can be used to better describe the physical setting. It would be useful to see geology, geomorphology, soils, vegetation, digital elevation maps, hypsometric curves of the watersheds in question, streamflow data, and precipitation data—especially storm events and water quality data for surface and groundwater over time and space. Various geographical information system maps would be useful here.

The salmon populations and habitat linkage needs to be better documented since many of the mine impacts are resulted from hydrologic modification. Figures 3-2A to 3-2E represent good thinking and an understanding of the linkages and potential effects of mining on these resources. The linkages to indigenous peoples is illustrated in Figure 3-2E, but little text is presented, referring the reader to the Appendix. The other conceptual models are not adequately addressed in the text. These flow charts provide an opportunity to present processes and linkages as related to potential effects of mine development activity and need to be developed within the text. Indeed, they seem to stand alone with little discussion of potential effects. Additionally, not all charts have adequate materials in the appendix for coverage, thus the variability in resource coverage is inconsistent and infers either a writing bias or data (lack of) bias.

The assessment concludes that a hydrologic modification will have detrimental salmon habitat consequences. The groundwater contributions to streamflows are important, both hydrologically and ecologically. Additional streamflow and groundwater data are needed to represent this linkage. Similarly, additional water quality data over time and space are needed and should include water hardness for metal standards. Depth to groundwater as related to streamflow, age dating of waters, and streamflow modeling would all be useful to illustrate the groundwater upwelling and hyporheic exchanges.

Site disturbance will be significant, yet there is no discussion of soil erosion. Soil erosion and subsequent suspended sediment transport would have the potential to have significant effects on water quality, channel delivery efficiency, salmon, salmon habitat, and metal transport. There is a generic discussion of road construction related to erosion, but road standards, road location, road usage, road maintenance (salting, grading, or watering), and length of roads would help in the risk assessment.

Are any endangered or threatened species present, either state or federally listed?

Roy A. Stein, Ph.D.

Overall Characterization. The characterization of the resources of the Nushagak and Kvichak watersheds was appropriate and accurate in the ecological arena save for the issues discussed below. Geological and cultural resources seemed adequately characterized, but they are not within my expertise. Finally, given the emphasis on these two watersheds (not the entire Bristol Bay watershed), might there be some consideration of a more circumscribed document title?

Broad Scale Comments:

Global Climate Change I. Risks to salmonids seem far greater than what is reviewed throughout this portion of the document. Missing, in my view, is any consideration of Global Climate Change, especially in light of the expected life of the mine (25-78 years), applied directly to the Bristol Bay Watershed (save for a brief mention on page 5-28, 2nd full paragraph). Given our current understanding, general changes likely include more intense precipitation events and increased temperature (and then of course, all that follows from these two changes and as models become more sophisticated, more specific geographically localized impacts could be assessed). With more intense storms come a greater likelihood of a failure of Tailings Storage Facilities (i.e., commensurate with more frequent and more intense flooding), more acidity from Pre-Tertiary waste rock (which will enter quite vulnerable, poorly buffered streams), and greater sediment influx into streams (and increasing fines in the gravel by as little as 5%, quite a small proportion, "…causes unacceptable effects on salmonid reproduction" (page 8-6; also see Chapter 7), which could occur during "routine operations", especially in light of the fact that sediment influx into streams is a cumulative process). Increased stream temperatures, depending on the absolute increase over a period of 78 years (and beyond, see "in perpetuity" comments below), could lead to reductions in salmon spawning success, as extant populations are specifically adapted to the current temperature regime. As is apparent, both increasing intensity of storms and increasing temperature will likely compromise salmon spawning success, and growth and survival of their offspring in the freshwater environment of Nushagak and Kvichak rivers.

What this would entail, at the very least, is a discussion of a monitoring system to quantify the impacts of Global Climate Change whose impacts on the ecosystem can then be differentiated from mine impacts. My concern is that if the mine is built, all negative impacts of the mine on salmonids, etc., could be attributed to Global Climate Change rather than the true culprit which would be the mining activities.

Global Climate Change II. Indeed, climate change is affecting Alaskan salmon as demonstrated (in a paper that just appeared online July 11, 2012) by a loss of a late-migrating population of pink salmon in a small stream near Juneau, in favor of an early-migrating one. Genetic evidence supports this explanation for Kovach et al. (2012) had 17 generations of data (since 1979) showing the reduction of the September spawners in favor of the late-August ones in response to increasing stream temperatures. As Kovach et al. (2012) write in their concluding paragraph:

> "We no longer observe the clear phenotypic distinction between early- and late-migrating individuals that was once present in the system. Apparently, the very-late-migrating phenotype has been greatly reduced or potentially lost. Although microevolution may have allowed this population to successfully track environmental change, it may have come at the cost of a decrease of within-population biocomplexity – the loss of the late run. This is not a surprising result; by definition, directional selection will decrease genetic variation. However, it does highlight the importance of maintaining sufficient genetic and phenotypic variation within populations in order for them to have the ability to respond to environmental change."

The ramifications of this work are obvious. As pointed out in the report (pages ES-8, 2-22, 5-28 as just a few examples), the exceptional quality of the Bristol Bay salmon stocks depend on the pristine quality of a set of quite diverse aquatic habitats, which has led to the development of genetically diverse stocks of salmon within species, each uniquely adapted to particular habitats. Reducing this variability by mining on top of the rivers that produce >50% of the wild sockeye salmon in Bristol Bay serves to reduce the flexibility with which these stocks respond to any environmental change (most notably Global Climate Change), and most notably during the time course of the Pebble Mine.

Groundwater Exchange. One of the key aspects of this system is the importance of groundwater exchange with surface streams and this groundwater contributes mightily to salmonid egg incubation success and survival (page 2-21). Simultaneous with this is the fact that the water demands of the proposed mine will require more than just surface waters available to it, but rather the mine will have to exploit groundwater resources to support its operations. This is yet another risk to salmonid success for reduction in the availability of groundwater will lead to increased temperatures in summer (see pages 3-7, 5-28, 5-29) and less inviting overwinter habitats (pages 5-20, 5-29), further exacerbating both mining and climate change effects.

Exploration Effects. During the public testimony segment, several Alaskan Natives argued that impacts owing to exploration have already occurred. A series of points were made: 1) exploration equipment was left behind, despoiling the landscape, 2) noise from helicopters frightened moose making them less vulnerable to exploitation, and 3) habitat change has already begun just due to exploration activities.

"In Perpetuity." Following up on the idea of increased risk (see previous points) to salmon, I struggled with the idea of this mine being monitored and maintained "in perpetuity" (e.g., pages ES-2, 4-32, 4-34). First, this relates directly to the Global Climate Change issues, in that these changes likely will continue to build through time, further exacerbating negative impacts on salmon. Even without climate change, salmon are in peril from mining operations in the Nushagak and Kvichak rivers; with climate change, the cards are stacked against them.

Second, what regulatory or institutional mechanisms currently available place the responsibility of these efforts on the corporation "in perpetuity"? Because mining companies come and go, might there be mechanisms that come into play if this particular company goes bankrupt? Might there be some sort of bonding process that protects the environment from the mine's remains into the long-term future? If not, should new legislation be pursued? Acknowledgement of this important issue should be front and center in the document, in my view.

Third, I began the review process with idea that the mine would be built, would capture its resources, and then would end by restoring the site. The scenario that includes monitoring and maintenance 1,000 years into the future continues to bother me. One solution that comes to mind is that Federal or state government would be charged with these monitoring and long-term maintenance activities, paid for by a hefty tax on the minerals removed from this site.

Finally, I am not encouraged by any of the text surrounding this issue, the two most relevant quotes (pages 4-31 and 5-45, respectively) being:

> "There are no examples of such successful, long-term collection and treatment systems for mines, because these time periods (100's to 1000's of year) exceed the lifespan of most past large-scale mining activities, as well as most human institutions."

> "We know of no precedent for the long-term management of water quality and quantity on this scale at an inactive mine."

And, finally, a quote from Chapter 8 on page 8-13:

> "The promises of today's mine developers may not be carried through by future generations of operators whose sole obligation is to the shareholders of their time (Blight 2010)."

William A. Stubblefield, Ph.D.

The EPA's assessment document presents a seemingly comprehensive compilation of the data associated with the ecological, geological, economic, and cultural resources of the Bristol Bay area. The characterization as presented seems to provide appropriate background information for the assessment considering the hypothetical nature of the evaluation. Without having specific knowledge of the area in question, it is not possible to provide an assessment as to whether the characterization was accurate. I'm unaware of significant literature, reports, or data that were specific to the site and would be useful for consideration. The assessment should be expanded to include greater detail regarding the environmental aspects of the site.

Dirk van Zyl, Ph.D., P.E.

The geological information was taken from documents prepared to conform to and in compliance with the standards set by National Instrument 43-101 (NI 43-101) (Ghaffari et al., 2011). This regulatory instrument emphasizes resource information for projects. While I cannot comment on the accuracy of the regional geological information, the document should reflect accurate geological information of the Pebble District as known at the time when the report was prepared.

My review did not include the Environmental Baseline Document (EBD) of the PLP. However, in scanning that document, it seems that more site-specific information on site hydrogeology may be available than was described in the EPA Assessment. While the latter refers to the EBD extensively in terms of fish populations, etc., it does not refer to it for much of the site physical characterization. EPA should address this in edits to the Draft Assessment.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment presents a well-documented discussion of the fish and wildlife resources of the Nushagak River and Kvichak River Watersheds, with more limited discussions of the remainder of the Bristol Bay Watershed. The document discusses interactions among species, including nutrient flows and the importance of groundwater systems; however, information on contributions of marine-derived nutrients and existing pressures on the environment are not as complete, or lacking. The information is general in nature. Should mine development go forward, it will be necessary to obtain ecological information specific to the potentially affected areas. The information should include timing of fish spawning, egg hatch, in-migration and out-migration, and similar specific life-history information for important wildlife species.

The discussion on the cultural resources is outside my areas of expertise and I cannot provide meaningful comments.

Paul Whitney, Ph.D.

Fish Population Estimates. There are several places in the text where impacts of the loss and degradation of habitat on fish populations was not quantified because of the lack of demographic data for salmonids (e.g., page ES-26, third bullet). These statements are only partially accurate. It is true that population models such as life tables or Leslie matrices require population age class data to estimate population numbers. However, even if demographic data are available, these population models do not relate population estimates to habitat quality. Incomplete data and relating fish population estimates to habitat quality are not an uncommon problem in ecology and there are many approaches for dealing with this issue. Approaches such as Ecosystem Diagnosis and Treatment (McElhany et al. 2010), Expert Panels (Marcot et al. 2012), Bayesian nets (Lee and Reiman 1997), Discussion with experts (Appendix G), or Weighing Lines of Evidence (Section 6.1.5) are just some of the methods for relating habitat quality to fish abundance. Models and expert opinions, of course, bring their own uncertainties but it seems better to have quantitative estimates (and discussion of the estimates) of all the potential fish losses due to habitat loss than no estimate at all.

Even though the Executive Summary indicates that the impacts of loss and degradation of habitat on fish populations could not be quantified, the text does provide some estimates. For example, the assessment (page 6-11, first full para) estimates "that the combined effects of direct losses of habitat in the North Fork Koktuli, down stream in the mainstem Koktuli and beyond, and impacts on macroinvertebrate prey for salmon could adversely affect 30 to 50% of Chinook salmon returning to spawn in the Nushagak River watershed." This type of statement, and the basis for the statement followed by a discussion of uncertainty, is a good example of the estimates that would better describe possible impacts of the example mine on salmonids. Another example estimate appears on page 6-39 for four species of salmon.

Question 2. A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

David A. Atkins, M.S.

The hypothetical mining scenario presented in the Assessment is based on a "Preliminary Assessment Technical Report" of the Pebble deposit prepared for Northern Dynasty Minerals by Wardrop (referred to as Ghaffari et al. 2011), in conformance with Canadian National Instrument 43-101 (NI 43-101) which is used to set standards for public disclosure of scientific and technical information about mineral projects of companies on bourses supervised by the Canadian Securities Administrators. By most accounts, the Pebble deposit is a world-class deposit and the Wardrop report counts nearly 11 billion tonnes of total resource. It is unlikely that all the ore currently identified would be mined, so 11 billion tonnes would be an upper bound for this particular deposit. It is also certain that exploiting the Pebble deposit would have to be at a scale large enough to justify the capital investment to build an infrastructure in such a remote area. Although the Assessment is ostensibly about any mining development in the Bristol Bay watershed, the use of the Wardrop scenario for Pebble effectively makes the report an assessment of mining the Pebble deposit.

The question then becomes what size mine is feasible from a technical and economic point of view. The Pebble deposit mine plan, as presented in the Wardrop report, outlines three scenarios:

- An "investment decision case" for a 25-year mine life that would mine 2 billion tonnes of ore;
- A "reference case" for a 45-year mine life that would mine 3.8 billion tonnes of ore; and
- A "resource case" for a 78-year mine life that would mine 6.5 billion tonnes of ore, or 55% of the total measured, indicated and inferred resource.

The Assessment chose minimum and maximum mine sizes of 2 billion and 6.5 billion tonnes of ore, respectively. Thus, the resource estimate used for the Assessment is the same as that for the two end members presented by Wardrop. This would make the mine one of the largest in the world, exceeding the size of the 10th percentile of global porphyry copper deposits by an order of magnitude (see Appendix H of the Assessment). Mines that ultimately become this size usually expand by increments, as exploration discovers new ore zones and expansion permits are granted.

The Wardrop report further delineates Pebble West as a low-grade deposit near the surface that would most efficiently be mined using open-pit methods, with Pebble East as a deeper, higher-grade deposit that would most efficiently be mined using underground methods (specifically block-caving). Mine facilities, as outlined in the Wardrop report, would include:

- Open-pit mining utilizing conventional drill, blast and truck-haul methods for near-surface deposits.
- Underground, block-cave methods for deeper deposits.

- A process plant with throughput of 200,000 tonnes/day that utilizes conventional crush-grid-float technology with secondary gold recovery.
- Other mine-site facilities, including:
    - Tailings storage.
    - Waste rock storage (the estimated waste/ore strip ratio is 2:1).
    - A natural-gas fired power plant.
    - Shop, office, and camp buildings.
    - Pipelines to ship ore concentrate slurry to the port facility; return water from the tailings slurry after separation at the port facility; and fuel.

This mining and ore processing approach is conventional, and the Assessment includes these elements. A mine developer may present alternative plans that could vary or alter how the mine is developed, but the fundamental components would most likely remain the same.

Because the Assessment is presented as a general assessment of mining risks and impacts in Bristol Bay and not a specific analysis of the Pebble Project, reliance on the scenario presented in Wardrop makes the assessment overly specific. Further, Chapter 7 provides more specific information on "Cumulative and Watershed-Scale Effects of Multiple Mines," which presents analysis of potential impacts from mining five additional deposits in various stages of development (presumably from early exploration to pre-feasibility). The information presented in Chapter 7 seems more like another mining scenario than a cumulative impacts assessment. Therefore, I would suggest a broader range of potential mining scenarios be organized as follows, with the detail of assessment necessarily becoming more speculative with each subsequent scenario in the list (due to the lack of geologic and engineering information on the other deposits):

- Development of one, average-sized porphyry copper deposit (50^{th} percentile or 250 million tonnes of ore as described in Appendix H) in the location of the Pebble deposit.
- Development of a mega-mine in the location of the Pebble deposit (of the range between 2 and 6.5 billion tonnes of ore) that may develop after multiple expansion and permitting cycles.
- Development of a mining district consisting of an average-sized Pebble mine and other potential mines (i.e., those presented in Chapter 7).
- Maximum development of all identified potential resources to their most likely ultimate extent.

Considering this broader range of scenarios would help the reader to better understand the range of potential risks and impacts.

Steve Buckley, M.S., CPG

Additional mine scenarios are necessary to appropriately bound the magnitude of potential mine activities. The maximum mine size in the mine scenario seems appropriate given the existing public information on the Pebble deposit. The minimum mine size of 2 billion tons exceeds the 90^{th} percentile of global porphyry copper deposits. Using a minimum mine scenario in the range of 250 million tons or in the 50^{th} percentile range of global porphyry copper deposits would be more appropriate to bound the lower end of the magnitude of potential mine activities. It would also be useful to include some variation in mining methods. This could include incremental development of a smaller open pit in the lower grade zones of a deposit, along with a portion of the higher grade deposit being mined by underground block caving methods to further assess the minimum potential impact of the mine scenario.

Courtney Carothers, Ph.D.

The hypothetical mine scenario was closely based on a probable mine prospect under development. As such, it appears to be realistic and sufficient, if challenging to conceptualize as fully hypothetical given this association.

The report notes that the Pebble deposit may exceed 11 billion metric tons (4-17). The rationale for choosing 6.5 billion metric tons as a maximum size is based "most likely mine to be developed (4-19)." The rationale for not choosing a higher potential maximum could be explained.

Dennis D. Dauble, Ph.D.

The hypothetical mine scenario initially appeared realistic and useful in terms of potential project scope. However, it was apparent during the public hearing, and upon further discussion between members of the panel, that assumptions on mine size should be revisited based on deposit characteristics and extraction potential. Also, assumed practices and operations should be verified against current best-practice and State of Alaska permitting guidelines.

Referenced literature provides appropriate context, however, I cannot help believe that information on environmental impacts from past mining activities conducted in the Rocky Mountain metal belt would be relevant to this assessment in some cases. It is also possible that recent published information from Holden Mine in northern Washington State would help establish context for effects of leachates and model results that predict downstream transport of tailing material in a wilderness setting, for example.

Gordon H. Reeves, Ph.D.

I am not familiar with this subject area and unable to comment on how realistic or sufficient the hypothetical mine scenario was.

Charles Wesley Slaughter, Ph.D.

Given the available information base for the ore deposits of the Bristol Bay watershed, and the publicity which has attended the Pebble planned development over the past several years, the Assessment's hypothetical mine scenario seems fairly realistic. Further, it is appropriate that the Assessment consider the probable impacts of other future mineral development projects once an initial entry (presumably Pebble-Northern Dynasty Minerals) has been accomplished. Such subsequent development – "cumulative effects over a long time period" – could (and should) receive **more** emphasis than is accorded in the Assessment.

John D. Stednick, Ph.D.

The document does not adequately bound the range of mine scenarios. The minimum mine development scenario is not adequately addressed. A frequent criticism during the public comment session was that mine plans presented in the assessment are not representative of current standards. A *compilation* of existing world porphyry mine complexes as well as other types of mines specific to Alaska would better inform the reader of mining processes and potential risks. The physical setting in Southwest Alaska is not the same as the Bingham Mine in Salt Lake City. Currently, the document refers to a particular mine in a particular risk assessment (stressor), e.g., the Fraser River for salmon, Aitika for chemistry, and Altiplano for pipeline failures.

The Bureau of Land Management has identified certain lands that will be excluded from development. This reference needs to be followed up.

Roy A. Stein, Ph.D.

Hypothetical Mine Scenario. Though mining does not lie within my area of expertise, I thought that this scenario helped me understand the potential impact of a mine of this magnitude in a wilderness, pristine watershed. I find it difficult to comment as to whether this scenario is realistic and sufficient, though I did use this scenario to guide my comments below. From the text, it is apparent that this is a realistic scenario, based on documents filed by the company with the Canadian government. This makes this scenario the most realistic one could expect.

a. **Minimum and Maximum Mine Size.** For me, as an ecologist, this bounding helped me to understand the potential impacts of the Pebble Mine, though I did not understand what the probability of either mine size happening in the near term. Understanding these probabilities would be helpful to the readers.
b. **Mine-Size Continuum**. Is it more likely that the initial Pebble Mine will be maximum or minimum in size? Wouldn't it be far better to review a continuum of mine sizes from the smallest that is economically feasible to one that is intermediate in size and then to one (or two) that would take to the largest realistic mine size? With this continuum, the reader begins to understand the overall impact of various mine sizes on the Bristol Bay ecosystem. Some reflection on these mines sizes and their impacts would have helped me interpret the Environmental Risk Assessment with some additional insight.

One Watershed. Given the productivity of salmon from these two river systems (50% of the sockeye salmon in Bristol Bay are produced from these rivers), might there be some thought given to limiting the mining operations to a single watershed, either the Nushagak or the Kvichak (page ES-2)? In so doing, in a single stroke, the impact of this mine on salmon is reduced by 50% or more. Could the Pebble Mine be confined to one watershed, such as where the majority now falls – in the Nushagak River (both the north and south forks of the Koktull River) watershed? Even so, this suggestion becomes especially pertinent to Chinook salmon spawning in the Nushagak River, for this run is "near the world's largest" (page ES-5), but yet the Nushagak watershed is small relative to other watersheds (such as the Kuskokwim and the Yukon) where Chinook salmon are abundant. As a result, any impacts to the watershed by a mine of this size are magnified, another concern when considering this location. Without mining expertise, I cannot judge whether it would be possible to mine in only one of the watersheds, rather than both. Even so, some consideration should be given to this suggestion.

William A. Stubblefield, Ph.D.

The hypothetical mine scenario proposed in the document seemed plausible; however, the evaluation of the proposed mine is outside my area of expertise and I can provide no judgment regarding its potential realism. Other members of the review panel are more knowledgeable about mine engineering.

Dirk van Zyl, Ph.D., P.E.

The hypothetical mine scenario adopted by the EPA relied almost exclusively on the document prepared for Northern Dynasty Minerals (NDM), one of the partners of the Pebble Limited Partnership. Developing a mine plan for a specific ore body is a large task and is undertaken by a large team of engineers and scientists. In the process of developing a mine plan many options are considered for each facility and its components, including mining methods, process design options, waste rock management options, tailings management options, shipment of product, etc. The hypothetical mine scenario was prepared by an independent consulting company for one of the partners and this plan does not necessarily represent the design and management options that will be selected for developing this ore body. Because of ore grades and the deposit style, it is most likely that an open pit mine will be developed as assumed in the report for the western lower grade ore body and that underground mining will be used for the eastern higher grade ore body. The size of the ore body and the strip ratio for an open pit mine are completely dependent on metal prices and production costs at the time of mine development. Metal prices and production costs will also be a major factor in deciding whether to first develop an underground mine instead of an open pit mine. While some of the components of the final mine may contain elements of the conceptual mine, it is impossible to know whether the hypothetical mine scenario is realistic, as will be further discussed in the comments below.

To address the issue of sufficiency it is necessary to understand the range of potential outcomes related to the various options. For the most part, the EPA study used the information from the NDM document for evaluating impacts to salmonids. Using different options, both technological as well as site selection, for some or many of the facilities could result in impacts that are different from those described in the report. I would therefore suggest that using only the present hypothetical mine scenarios is insufficient. There could be a range of impacts, such as the surface areas of facilities, which in some cases could be smaller than what was chosen and in other cases larger. However, this does not mean that the hypothetical mine represents "average conditions." I therefore consider the mine scenario not sufficient for the assessment.

The minimum and maximum mine sizes selected by EPA are 2 billion tonnes mined over 25 years and 6.5 billion tonnes mined over 78 years; in both cases, the daily ore processing rate is 200,000 tonnes. As indicated above, the final economic mine size at the time of development will be determined by metal prices and production costs. Note that production costs, as used here, include all the considerations related to regulatory, environmental and social aspects of the mine and its environs. Mining companies typically make investment decisions for periods of 20 to 30 years. It is seldom, if ever, that a new investment will be made based on a 78 year mine life; however, the upside potential will be taken into account when an investment for a shorter mine life is made. It is also unlikely that environmental regulatory agencies will consider issuing a permit, including closure plans, etc. for a 78-year project. Furthermore, even if the mine ultimately continues for 78 years, it is certain that the operating and environmental control technologies and societal expectations will change in that period and therefore the elements used by EPA for the maximum size hypothetical mine will certainly not be valid for such a long mine life. It is therefore my conclusion that assuming the development of a 2 billion tonne ore body is realistic, but that assuming development of a 6.8 billion tonne ore body, using static technology assumptions, is not.

The EPA assessment report includes a range of the literature and reports in evaluating the selected mine scenario. However, I have a number of specific comments about various aspects of the report as well as the references.

Good practice vs. best practice. On p. 4-1 of the report, the EPA states: "Described mining practices and our mine scenarios reflect the current practice for porphyry copper mining around the world, and represent current good, but not necessarily best, mining practices". EPA does not clarify this decision, nor does the report clarify the distinction between "good" and "best" practices. It can only be concluded that "best" will be better than "good". On the basis of this, it is inconceivable to me that the Bristol Bay communities, the Alaska regulatory authorities as well as Federal Regulatory Authorities will not demand that the company follow "best mining practices", however that is defined at the time. It is also inconceivable to me that the company will not follow "best mining practices" in the design and development of such a mine. During the engagement processes, the stakeholders will have to agree what represents "best" practice in the design of the mining project. It is important to note that most of the failure statistics used as a basis for the evaluations in the report are derived from data gathered over the last 50 years or so (e.g. refer to p. 4-45 of report). It may be argued that this information is mostly for mines following "good" practices and, in many cases, for projects that had a lower standard of care. To my knowledge, there are no statistics available that compare failure rates of facilities designed and operated under "good" practice to those designed and operated under "best" practices, whatever definitions are used for "good" and "best".

Mine scenarios. The executive summary indicates (p. ES-11): "The mine scenario includes minimum and maximum mine sizes, based on the amount of ore processed (2 billion metric tons vs. 6.5 billion metric tons), and approximately corresponding mine life spans of 25 to 78 years, respectively". This seems to indicate that the mine life cycle in the first case consists of 25 years of operational life followed by closure and, similarly for the second case, 78 years of operational life followed by closure. However, a careful review of the water management section (section 4.3.7) indicates that this is not the case. The EPA water balance calculations are simplified to a set of deterministic values in Table 4-5 for four water management stages during the overall mine life cycle: start-up, operations minimum mine (25 years), operations maximum mine (78 years), and post-closure. For post-closure, only the 78-year mine life numbers are used. It therefore seems that EPA is not considering that the 25-year mine will close, but that its life will automatically be extended to 78 years. Does this mean that the EPA really does not evaluate the minimum mine size completely, i.e. the 25-year mine life followed by closure? It is important that this be clarified as it would be inconsistent not to evaluate closure of the 25-year mine. It is possible that additional evaluations, or at least additional explanations, will be required to clarify this.

Tailings management technologies. Ongoing technology development has resulted in a broader range of tailings management options than only slurry tailings disposal. Filtered dry stack tailings can be considered as a realistic option, even for mines with higher production rates. Flotation of remaining sulfides in the tailings before deposition is also a realistic option for mines; it has been done successfully at the Thompson Creek Mine in Idaho for the last 18 plus years. While these technologies are mentioned, they are not selected for reasons such as technology not being appropriate for the climatic conditions and concerns with disposal of pyrite waste. Both of these are not insurmountable technical issues and adopting such management options will reduce failure probabilities and potential impacts following a failure. The failure mode of a filtered dry stack facility not containing sulfides will be completely different from a slurry impoundment and the potential environmental impacts of these other tailings management options will definitely be far smaller than those for the selected mine scenario using slurry tailings disposal.

Waste rock management. The waste rock management plan on p. 4-13 calls for the potentially acid generating (PAG) waste rock to be separated from the rest of the waste rock and states that the "PAG waste rock might be placed in the open pit at closure to minimize oxidation of sulfide minerals and generation of acid drainage". However, on p. 4-33 it is stated that: "PAG waste rock will be processed through the flotation mill prior to mine closure, with tailings placed into the TSF (tailings storage facility) or the mine pit." These two alternatives represent completely different management, economic and environmental conditions and are not consistent. Milling the PAG waste rock represents a higher cost than placing the PAG rock in the pit and placing the PAG waste rock tailings in the TSF will increase the size of the TSF. Placing the PAG tailings in the pit will set up a completely different management scenario than placing the PAG waste rock in the pit. The EPA should clarify which option or range of options they select for evaluation and use that consistently in the assessment.

Water balance and management – waste rock. Mine site water balance and management is a very complex issue as recognized by the EPA on p. 4-27: "…water balance development is challenging and requires a number of assumptions". Because of these uncertainties, complex probabilistic dynamic models are employed at mines where the site details are better defined than that of the EPA hypothetical mine scenario. The information in Box 4-2 indicates that the "captured flows include water captured at the mine site and the TSFs (Table 4-5). The total amount of water captured at the mine site includes net precipitation (precipitation minus evapotranspiration[1]) over the areas of the mine pit, the waste rock piles, and the cone of depression (without double-counting any areas of overlap)". On p. 4-23 it is stated that: "Monitoring and recovery wells and seepage cut-off walls would be placed downstream of the piles to manage seepage, with seepage directed either into the mine pit or collection ponds". Figure 4-9 shows this schematically where leachate from the waste rock enters the groundwater that then flows to the mine pit or to the monitoring and collection well. However, if net precipitation only includes the components above (precipitation minus evapotranspiration), effectively excluding infiltration, and if this net precipitation is captured from that waste rock pile (as stated in Box 4-2), then there should not be any water available to infiltrate into the waste rock pile, i.e. there should not be any leachate. All references to seepage from the waste rock piles are incorrect following the EPA's assumptions of total capture of net precipitation. In addition, the approach that is used in the water balance is inconsistent with observed field performance and descriptions in the literature, as is it difficult to imagine a case where there is zero infiltration into a porous waste rock pile (e.g. Nichol et al., 2005 and Fretz et al., 2011). The EPA must clarify the whole water balance model and the evaluations. For the assessment to have any credibility, the water balance and management evaluations should reflect <u>realistic</u> conditions.

Dam failure – tailings storage facilities. During operations, "water falling within the perimeter of a TSF would be captured directly in the TSF, but runoff from catchment areas up-gradient of the TSF would be diverted downstream" (p. 4-27). At closure, water would be removed from the TSF providing more storage, but also maintaining a small pool to "keep the core of the tailings hydrated and isolated from oxidation" (p. 4-32). This seems to assume that the diversion systems will be kept in place and most likely will be upgraded to divert up-gradient surface water around the tailings impoundment. It is likely that the design criterion for the upgraded diversion system during the post-closure period will be the probable maximum flood (PMF) as is done at a number of mines. Dam failure analyses were done assuming that the flood leaving the TSF includes the

[1] During operations most of these areas will not be covered with vegetation and the correct terminology here is "evaporation". The correct terminology is used on p 6-37 of the EPA assessment.

PMF inflow from the up-gradient catchment, excess water on top of the tailings and 20% of the tailings volume (Box 4-8). While one can argue that a failure including all these materials may be a plausible, although a very low likelihood event during operations, it seems less probable that such a failure will take place for the mine closure period when an upgraded diversion system is in place. Also, during the closure phase, the tailings will consolidate and be less mobile. Note that the densification behavior of oil sand tailings referred to on p. 4-32 (i.e. the Wells, 2011 reference) does not apply to copper tailings. The presence of clay minerals and bitumen in the mature fine tailings portion of the oil sand tailings is the source of the different behavior (Znidarčić et al., 2011).

Reclamation slope of waste rock. On p. 4-32 it is stated that: "We assume that NAG waste rock would be sloped to a stable angle (less than 15%) (Blight and Fourie, 2003)". I contacted Profs. Geoff Blight and Andy Fourie about this statement and received the following response from Prof. Blight: "The only reference to 15 degrees (not 15 %) slopes is the following, talking about the outer tailings, not waste rock covered, slopes of decommissioned TSFs: "it must be remembered that the outer slopes will need to be rehabilitated, and that for vegetation to be stable, and surface erosion minimal, the maximum outer slope should not exceed 15 degrees." This error in reference must be corrected; it is recommended that more typical closure slopes of about 30% (or 3H:1V, about 18 degrees) for waste rock should be used in the evaluations.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment discusses a hypothetical mine (given that mine plans have not been developed). Page 4-5 of the document states that "rocks associated with porphyry copper deposits tend to straddle the boundary between net acidic and net alkaline . . ." The Pebble Project Environmental Baseline Report (SRK 2011, Chapter 11) summarizes testing on the samples from the pre-Tertiary porphyry mineralized rock in Pebble East Zone (PEZ) and Pebble West Zone (PWZ). The metals leaching/acid rock drainage study showed acidic conditions occurring immediately in core with low NP, but the average delay to onset of acidic conditions was estimated to be about 20 years. Copper was leached in the highest concentrations, but Co, Cd, Ni, and Zn also leached from samples from PEZ. Wacke (sedimentary rock) samples from PEZ and PWZ leached As, Sb, and Mo, in addition to Cu. (SRK, page 58). The available information on acid generation and metals leaching appears to be preliminary. Development and permitting of a viable mine plan will require extensive sampling and data analysis of ore samples, plans for classifying waste rock (as PAG and NAG), and, possibly, plans for collecting and treating runoff and seepage waters.

The Environmental Assessment seems a bit premature in making an assessment of the potential for acid rock drainage (ARD) or metals leaching (ML). Data on metals other than Cu are insufficient and possible toxicities to fish are not addressed. Further, the description of the potential mine may not reflect a likely mine scenario. It is difficult to calculate potential risks to the environment without a specific mine plan. The section of the Environmental Assessment should be revised as more data on ARD and ML become available.

Paul Whitney, Ph.D.

Reclamation Plan. I am not familiar with the Northern Dynasty Minerals mine plan. I wonder if their mine plan includes a Reclamation Plan. If not, why not? If their mine plan includes a Reclamation Plan, why isn't it presented as part of the Bristol Bay Assessment? The feasibility of reclaiming the waste rock and tailings areas and possibility the pit (page 4-23, last para, last sentence) seems important for evaluating the acceptability of the example mine. I am not aware of any mine regulating agency that does not require a Reclamation Plan as part of a mine application. I wonder if a Reclamation Plan that involved placing waste rock and tailings back in the pit and reducing surface infiltration would greatly reduce the need for water treatment.

Best Mining Practices. The assessment refers to the example mine plan as having both the "best" mining practices (e.g., page ES-10, five lines from the bottom) and "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). Both of these statements can't be accurate.

Noise Levels. The mine plan should provide information on the location, frequency, and size of blasting, sound level isopleths around the mine, and efforts to minimize sound levels as the mine develops. I wonder if a majority of the sound levels will attenuate as mining activities move deeper into the ground or if will there be a hundred years of blasting at the surface level. The interviews with the villagers indicate that blasting and helicopter noise is a concern (Appendix D, Cultural Characterization, page 94). A characterization of current noise levels in relation to the area and timing of current and past wildlife use would help to determine if the whole or parts of the watersheds are less than pristine.

Water treatment during the winter. I wonder if it will be possible to treat water during the winter. Will such treatment have to occur in a warm building? If so, what are the temperature consequences of releasing warm treated water into streams?

Cone of Depression. I have worked on pit mines where hydrogeologists model the lateral extent of the cone of depression and have mapped the lateral extent as an area around the pit. The lateral extent of the cone of depression, illustrated in Figure 4-9, appears to be underestimated and has no effect on streams or wetlands. The figure has no scale. Is the lateral extent of the cone of depression in Figure 4-9 based on modeling (see Box 4-2, para 3, last sentence)? If so, how many NWI wetlands and meters of stream are in the area used for the model? If there are wetlands or streams in the modeled area, how far down stream will the cone of depression influence stream flow and wetland hydrology?

The information in Box 4-2 doesn't clearly (at least to me) deal with the proportions of run-on and run-off water. If the diverted run-on water is supposed to mitigate the cone of depression. will it be available for down stream resources? Why won't diverted water seep back into the near-by pit versus mitigating the cone of depression? The answer to these questions is on page 5-72, but merely indicating there will be a reduction is not very informative.

Run-on and run-off water terminology. I am used to referring to up gradient or adjacent water that runs onto the pit or tailings facilities as run-on water and to water from the mine or storage facilities as run-off water. The assessment doesn't always distinguish these two types of water. For example, on page 4-13, line 6 refers to precipitation run-off water as up gradient water. On page 4-26, the first bullet refers to run-off water as water running off mine facilities. The terminology overlap makes it difficult (at least for me) to understand how the run-on and run-off water will be captured and diverted around the mine facilities or used for other purposes. In addition to calculations, diagrams of the diversions would be helpful. Will there be parallel diversion ditches around the facilities, one for run-on and one for run-off water? Will one or both of these ditches be lined? How will the water in these ditches be influenced by the cone of depression? These questions are alluded to in the discussion on page 4-27(second para), but are not explicitly addressed. I am sure engineers can and have answered these questions for other mines with water balance analyses. It would be interesting to see an explicit summary of the water balance for the various facilities. Such analyses would be good for the example mine plan during operation and once the mine is no longer a net consumer of water (page 5-44, para 2). Without the water balance analyses, potential impacts are not easily understood or quantifiable.

Some ideas for how to manage and separate run-on and run-off water might help determine which streams might dry up and what type of mitigation measures (i.e., lining ditches) could minimize the impact. In addition, if run-on water can be maintained in a diversion ditch, what is the opportunity for developing a reclamation plan for the ditches? Such plans might be able to minimize and partially compensate for lost reaches of headwater streams.

Protective approach. A "protective approach" is mentioned on page 5-30 (para 3, last sentence). This has something to do with water management and would be good to explain.